CLAIMS

What is claimed is:

1. An eddy current probe for detecting defects in an electrically conductive specimen under test (SUT), the eddy current probe comprising:

    a. at least one excitation coil having a cross-section disposed within a common plane, the at least one excitation coil having a symmetry axis within the common plane, wherein the at least one excitation coil creates a magnetic field and eddy currents into SUT; and

    b. at least one magnetic senor operable to be positioned on the symmetry axis of the at least one excitation coil and having a sensitive axis operable to be disposed within the common plane perpendicular to the symmetry axis of the at least one excitation coil.

2. The eddy current probe according to claim 1, wherein the at least one excitation coil comprises a substantially rectangular cross-section.

3. The eddy current probe according to claim 1, wherein the at least one excitation coil comprises a pair of substantially identical excitation coils symmetrically disposed about the symmetry axis.

4. The eddy current probe according to claim 3, wherein each excitation coil of the pair of substantially identical excitation coils comprises a substantially rectangular cross-section.

5. The eddy current probe according to claim 3, wherein the pair of substantially identical excitation coils are operable to be interconnected such that when an electric current is passed through the pair of substantially identical excitation coils, each excitation coil of the pair of substantially identical excitation coils create a magnetic field in the same direction.

6. The eddy current probe according to claim 3, further comprising a third excitation coil configured to be located between the pair of substantially identical excitation coils, wherein the three excitation coils are operable to be interconnected such that when an electric current is passed through the three excitation coils, the magnetic field created by the third excitation coil and the magnetic field created by the pair of substantially identical excitation coils are in opposite directions.

7. The eddy current probe according to claim 6, wherein each of the three excitation coils comprises a substantially rectangular cross-section.

8. The eddy current probe according to claim 3, wherein the pair of substantially identical excitation coils is operable to be configured such that they intersect.

9. The eddy current probe according to claim 1, wherein the at least one excitation coil comprises a flat coil having at least one layer.

10. The eddy current probe according to claim 9, wherein the flat coil comprises multiple layers.

11. The eddy current probe according to claim 1, wherein the at least one excitation coil comprises:

    a. a ribbon cable comprising a plurality of parallel insulated wires and having two ends;

    b. a pair of electrical connectors, each electrical connector attached to the ribbon cable; and

    c. a plurality of jumper wires operable to be attached to the electrical connectors to form the at least one excitation coil.

12. The eddy current probe according to claim 1, wherein the at least one excitation coil is patterned on an electrically insulated substrate.

13. The eddy current probe according to claim 1, wherein the at least one excitation coil is patterned from a metallic sheet.

14. The eddy current probe according to claim 1, wherein the at least one excitation coil comprises an electrically conductive foil.

15. The eddy current probe according to claim 1, wherein the set of excitation coils is patterned from a metallic sheet without an insulating substrate.

16. The eddy current probe according to claim 1, wherein the at least one magnetic sensor comprises a plurality of substantially identical magnetic sensors.

17. The eddy current probe according to claim 16, wherein the plurality of substantially identical magnetic sensors are operable to be disposed in a linear array.

18. The eddy current probe according to claim 1, wherein the at least one magnetic sensor comprises at least one magnetoresistive sensor.

19. The eddy current probe according to claim 18, wherein the magnetoresistive sensor comprises at least one giant magnetoresistive sensor, anisotropic magnetoresistive sensor, or spin-dependent tunneling sensor.

20. The eddy current probe according to claim 1, wherein the at least one magnetic sensor comprises at least one Hall-effect sensor

21. An eddy current testing system for detecting and monitoring defects in an electrically conductive specimen under test (SUT), the eddy current testing system comprising:

    a. an eddy current probe according to claim 1;

    b. an AC power supply electrically connected to the at least one excitation coil of the eddy current probe;

    c. an amplifier electrically connected to the at least one magnetic sensor of the eddy current probe;

    d. an amplitude and phase detector capable of receiving the signal from the amplifier.

22. The eddy current system according to claim 21, further comprising a data recorder in communication with the detector.

23. The eddy current system according to claim 21, further comprising a display in communication with the detector.

24. The eddy current system according to claim 21, wherein the amplitude and phase detector comprises a lock-in amplifier.

25. The eddy current system according to claim 21, wherein the amplitude and phase detector comprises program code stored on a computer readable media.

26. The eddy current system according to claim 21, wherein the eddy current probe comprises a plurality of magnetic sensors and wherein the eddy current testing system is operable to compute the sum of or difference between a plurality of output signals from the plurality of magnetic sensors.

27. An eddy current probe for detecting defects within a specimen under test (SUT) comprising:

a. a flat excitation coil of rectangular cross-section having an axis of symmetry within a plane of the cross-section; and

b. a linear array of magnetoresistive sensors disposed at the axis of symmetry of the flat excitation coil, each magnetoresistive sensor in the array having a sensitive axis operable to be disposed perpendicular to the axis of symmetry of the excitation coil.

28. A method for detecting defects within a specimen under test (SUT) comprising scanning an eddy current probe according to claim 1 above the top surface of the SUT, wherein the cross-section of the at least one excitation coil of the eddy current probe is coplanar with the top surface of the SUT.

29. A method for detecting cracks in a specimen under test (SUT) having at least one row of fastener holes, wherein each row of fastener holes has a symmetry axis that intersects the centers of all holes in the row, comprising scanning the eddy current probe according to claim 1 above the top surface of the SUT along the symmetry axis

of the fastener holes such that the at least one magnetic sensor passes along the symmetry axis of the row of fastener holes.

30. An eddy current probe comprising:

a. a flat excitation coil having a substantially rectangular cross-section and having an axis of symmetry within the plane of the cross-section;

b. two magnetoresistive sensors operable to be disposed at the axis of symmetry of the excitation coil, each magnetoresistive sensor having a sensitive axis operable to be disposed perpendicular to the axis of symmetry of the excitation coil, wherein the two magnetoresistive sensors are operable to be connected in a gradiometer configuration.

31. A method for detecting cracks in a specimen under test (SUT) having at least one row of fastener holes, wherein each row of fastener holes has a symmetry axis that intersects the centers of all holes in the row, comprising:

a. configuring the eddy current probe according to claim 30 such that the distance between the two sensors is substantially the same as the distance between the centers of two adjacent fastener holes; and

b. scanning the eddy current probe according to claim 30 above the top surface of the SUT such that the two magnetoresistive sensors pass along the symmetry axis of the row of fastener holes.

32. An eddy current probe for detecting defects in an electrically conductive specimen under test (SUT), the eddy current probe comprising:

    a. a pair of substantially identical excitation coils having substantially rectangular cross-sections operable to be disposed within a common plane, the pair of excitation coils having a first symmetry axis and a second symmetry axis orthogonal to the first symmetry axis within the common plane, wherein the pair of excitation coils are interconnected such that they create magnetic field and eddy currents into SUT in opposite directions if an electric current is passed through the pair of excitation coils; and

    b. at least one magnetic sensor operable to be positioned on the second symmetry axis of the pair of excitation coils and having a sensitive axis operable to be disposed within the common plane perpendicular to the second symmetry axis of the pair of excitation coils.

33. The eddy current according to claim 32, wherein the pair of excitation coils intersect.

34. The eddy current probe according to claim 32, wherein the pair of excitation coils comprises a flat coil having at least one layer.

35. The eddy current probe according to claim 32, wherein the pair of excitation coils comprises a flat coil having multiple layers.

36. The eddy current probe according to claim 32, wherein the pair of excitation coils comprises:

a. a ribbon cable comprising a plurality of parallel insulated wires and having two ends;

b. a pair of electrical connectors, each electrical connector attached to the ribbon cable; and

c. a plurality of jumper wires operable to be attached to the electrical connectors to form the at least one excitation coil.

37. The eddy current probe according to claim 32, wherein the at least one magnetic sensor comprises a plurality of substantially identical magnetic sensors.

38. The eddy current probe according to claim 32, wherein the plurality of substantially identical magnetic sensors are operable to be disposed in a linear array.

39. The eddy current probe according to claim 32, wherein the at least one magnetic sensor comprises at least one pair of substantially identical magnetic sensors symmetrically disposed about the first symmetry axis.

40. The eddy current probe according to claim 32, wherein the at least one magnetic sensor comprises at least one magnetoresistive sensor.

41. The eddy current probe according to claim 32, wherein the at least one magnetic sensor comprises at least one Hall-effect sensor.

42. An eddy current testing system for detecting and monitoring defects in an electrically conductive specimen under test (SUT), the eddy current testing system comprising:

a. an eddy current probe according to claim 32;

b. an AC power supply electrically connected to the pair of excitation coils of the eddy current probe;

c. an amplifier electrically connected to the at least one magnetic sensor of the eddy current probe; and

d. an amplitude and phase detector capable of receiving the signal from the amplifier.

43. The eddy current system according to claim 41, further comprising a data recorder in communication with the detector.

44. The eddy current system according to claim 41, further comprising a display in communication with the detector.

45. The eddy current system according to claim 41, wherein the amplitude and phase detector comprises a lock-in amplifier.

46. The eddy current system according to claim 41, wherein the amplitude and phase detector comprises program code stored on a computer readable media.

47. The eddy current system according to claim 41, wherein the eddy current probe comprises a plurality of magnetic sensors and wherein the eddy current testing system is operable to compute the sum of or difference between a plurality of output signals from the plurality of magnetic sensors.

48. An eddy current probe for detecting defects within a specimen under test (SUT) comprising:

a. a pair of flat excitation coils having a rectangular cross-section and having a first symmetry axis and a second symmetry axis orthogonal to the first symmetry axis within the plane of the cross-section; and

b. a linear array of magnetoresistive sensors disposed at the second symmetry axis of the pair of excitation coils, each magnetoresistive sensor in the array having a sensitive axis disposed within the plane of the cross-section, wherein the sensitive axis is perpendicular to the second symmetry axis of the pair of excitation coils.

49. An eddy current probe for detecting cracks in a specimen under testing (SUT) having a row of fastener holes, wherein the row of fastener holes has a symmetry axis that intersects the centers of all holes in the row, wherein the eddy current probe comprises:

a. a pair of flat excitation coils having rectangular cross-sections and having a first symmetry axis and a second symmetry axis orthogonal to the first symmetry axis within the plane of the cross-section;

b. a magnetoresistive sensor disposed at the intersection of the first symmetry axis and the second symmetry axis of the pair of excitation coils, the magnetoresistive sensor having a sensitive axis disposed within the plane of the cross-section, wherein the sensitive axis of the magnetoresisitve sensor is perpendicular to the second symmetry axis of the excitation coil.

50. A method for detecting defects within a specimen under test (SUT) comprising scanning an eddy current probe according to claim 32 above the top surface of the SUT, wherein the cross-section of the pair of excitation coils of the eddy current probe is coplanar with the top surface of the SUT.

51. A method for detecting cracks in a specimen under test (SUT) having at least one row of fastener holes, wherein each row of fastener holes has a symmetry axis that intersects the centers of all holes in the row, comprising scanning the eddy current probe according to claim 32 above the top surface of the SUT along the symmetry axis of the fastener holes such that the first symmetry axis of the excitation coils substantially coincides with the symmetry axis of the row of fastener holes.